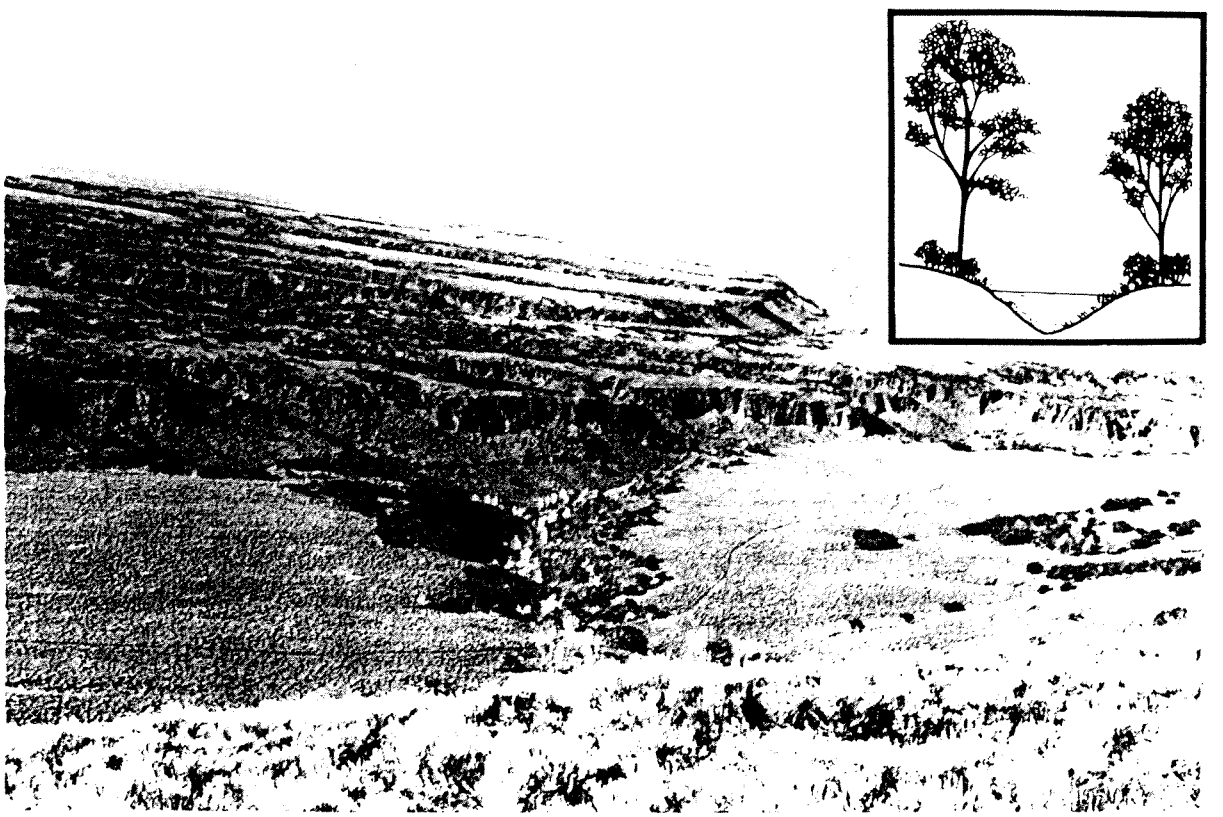
GENERAL TECHNICAL REPORT PNW-80

WILDLIFE HABITATS IN MANAGED RANGELANDS-- THE GREAT BASIN OF SOUTHEASTERN OREGON

RIPARIAN ZONES

JACK WARD THOMAS
CHRIS MASER
JON E. RODIEK



PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

This publication is part of the series **Wildlife Habitats in Managed Rangelands — The Great Basin of Southeastern Oregon**. The purpose of the series is to provide a range manager with the necessary information on wildlife and its relationship to habitat conditions in managed rangelands in order that the manager may make fully informed decisions.

The information in this series is specific to the Great Basin of Southeastern Oregon and is generally applicable to the shrub-steppe areas of the Western United States. The principles and processes described, however, are generally applicable to all managed rangelands. The purpose of the series is to provide specific information for a particular area but in doing so to develop a process for considering the welfare of wildlife when range management decisions are made.

The series is composed of 14 separate publications designed to form a comprehensive whole. Although each part will be an independent treatment of a specific subject, when combined in sequence, the individual parts will be as chapters in a book.

Individual parts will be printed as they become available. In this way the information will be more quickly available to potential users. This means, however, that the sequence of printing will not be in the same order as the final organization of the separates into a comprehensive whole.

A list of the publications in the series, their current availability, and their final organization is shown on the inside back cover of this publication.

Wildlife Habitats in Managed Rangelands — The Great Basin of Southeastern Oregon is a cooperative effort of the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Introduction

Riparian zones can be identified by the presence of vegetation that requires free or unbound water or conditions that are more moist than normal (fig. 1) (Franklin and Dyrness 1973, Minore and Smith 1971). Riparian zones can vary considerably in size and vegetative complex because of the many combinations that can be created between water sources (fig. 2) and physical characteristics of a site. Such characteristics include gradient, aspect, topography, soil, type of stream bottom, water quality, elevation, and plant community (Odum 1971). All riparian zones within managed rangelands of the western United States, however, have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass—plant and animal—than the remainder of the area; and (4) they are a critical source of diversity within rangelands (fig. 3). Carothers (1977), Carothers and Johnson (1975), and Curtis and Ripley (1975) have prepared summary papers on the subject of riparian habitats as associated with both range and forest areas.

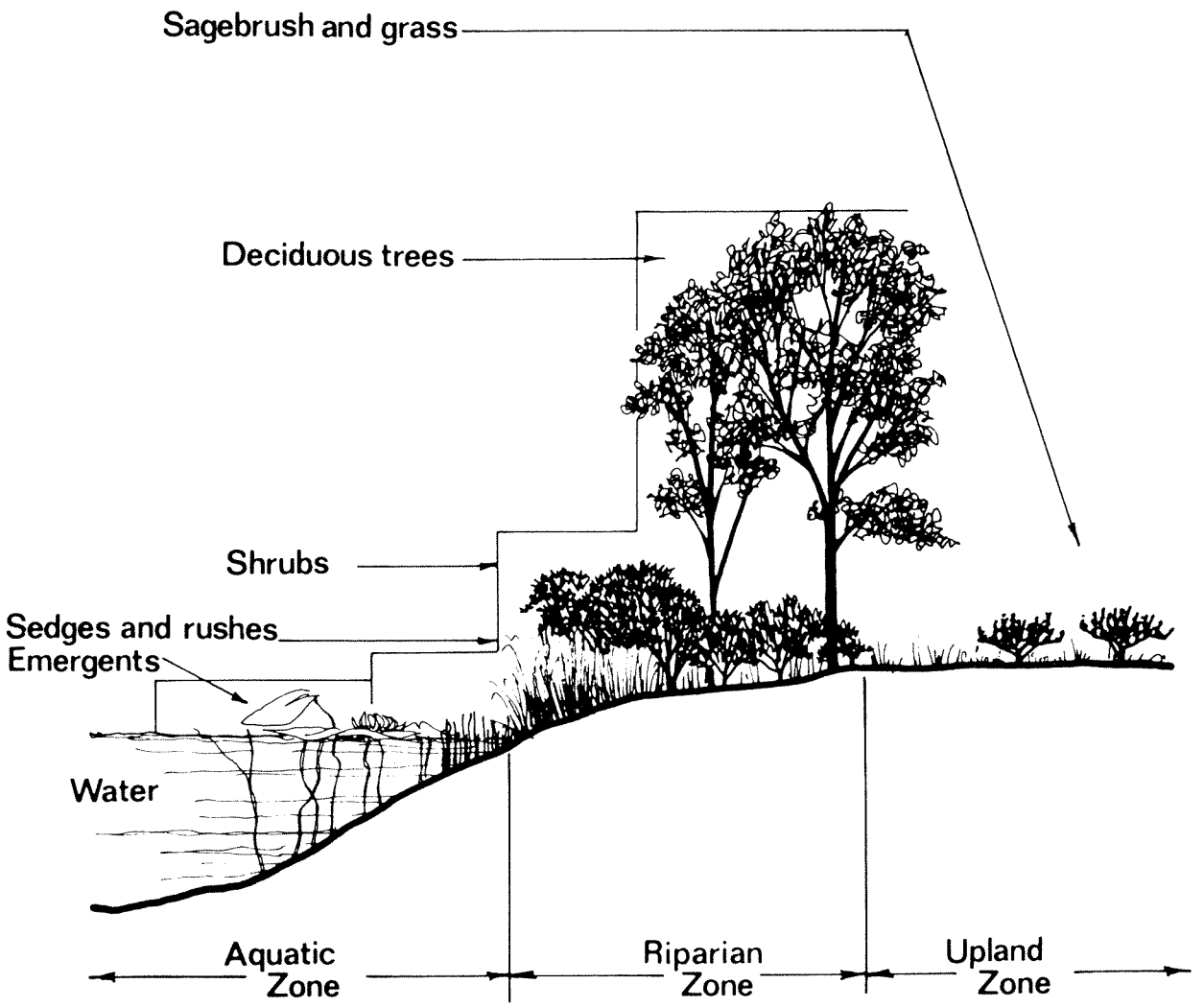


Figure 1.—Riparian zones are identified by the presence of vegetation that requires large amounts of free or unbound water.

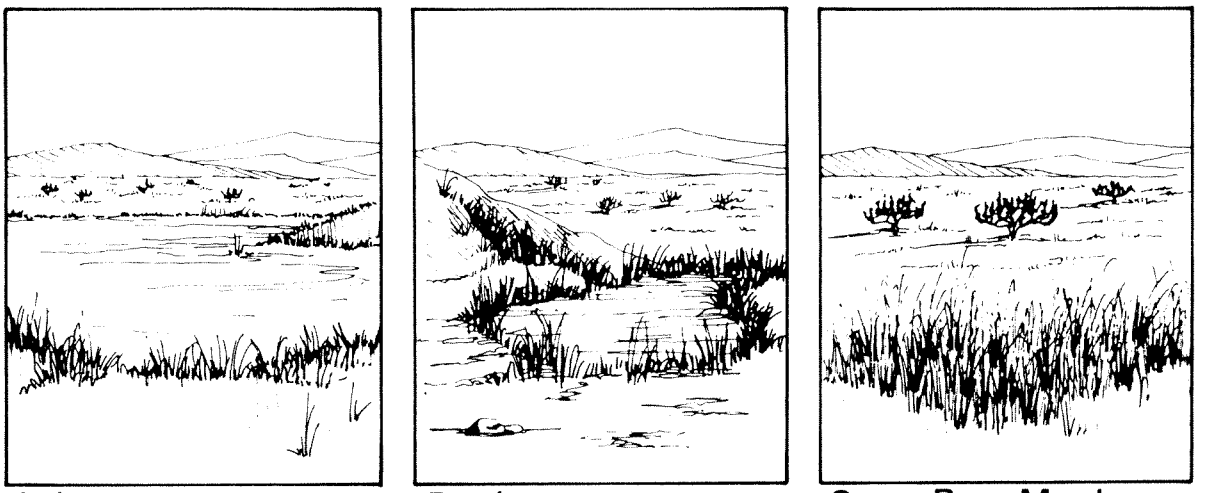
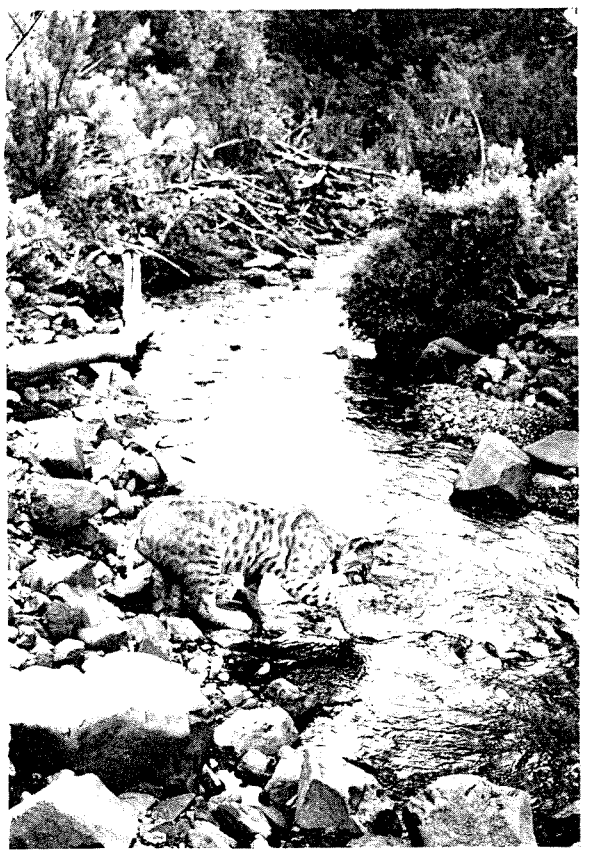


Figure 2.—The type of water source influences riparian vegetation (Odum 1971, p. 295).

IMPORTANCE OF RIPARIAN ZONES

Wildlife use riparian zones disproportionately more than any other type of habitat (Beidleman 1948 and 1954, Bottorff 1974, Dumas 1950, Gains 1977, Hinschberger 1978, Hubbard 1977, Kelley et al. 1975, Kirby 1975, and Wooding 1973). For example, of the 363 terrestrial species known to occur in the Great Basin of Southeastern Oregon, 288 are either directly dependent on riparian zones or utilize them more than other habitats (fig. 4). Many aquatic and semi-aquatic species are found nowhere else. Among such species are waterfowl and mammals, such as otter (*Lutra canadensis*), beaver (*Castor canadensis*), and muskrats (*Ondatra zibethicus*). Vertebrates that either reproduce or feed in water are totally dependent on riparian and adjacent

Figure 3.—Riparian zones are a critical source of diversity on western managed rangelands. Note the beaver (*Castor canadensis*) lodge in the upper right of the picture. (Robert R. Kindschy photograph).



aquatic zones. Of course, the water in these zones is the habitat for aquatic life forms—from invertebrates to fish, reptiles, amphibians, birds, and mammals. In short, riparian zones are the most critical wildlife habitats in managed rangelands.

Riparian zones in managed rangelands are also disproportionately important for other uses (fig. 5). Stream margins frequently contain highly productive forage sites. Cattle use the vegetation in riparian areas more heavily than that in other areas (Ames 1977, Kennedy 1977) because they concentrate in riparian areas to drink. The relative gentle topography, particularly in areas of otherwise rugged topography, makes riparian zones attractive for road locations. Streams, rivers, and their banks are also handy sources of rock and gravel for building roads. Mining has and does have direct and indirect impacts on riparian zones (Hill 1974) (fig. 6). Recreationists concen-

Figure 4.—Wildlife uses riparian zones disproportionately more than any other habitat type. (Robert R. Kindschy photograph).

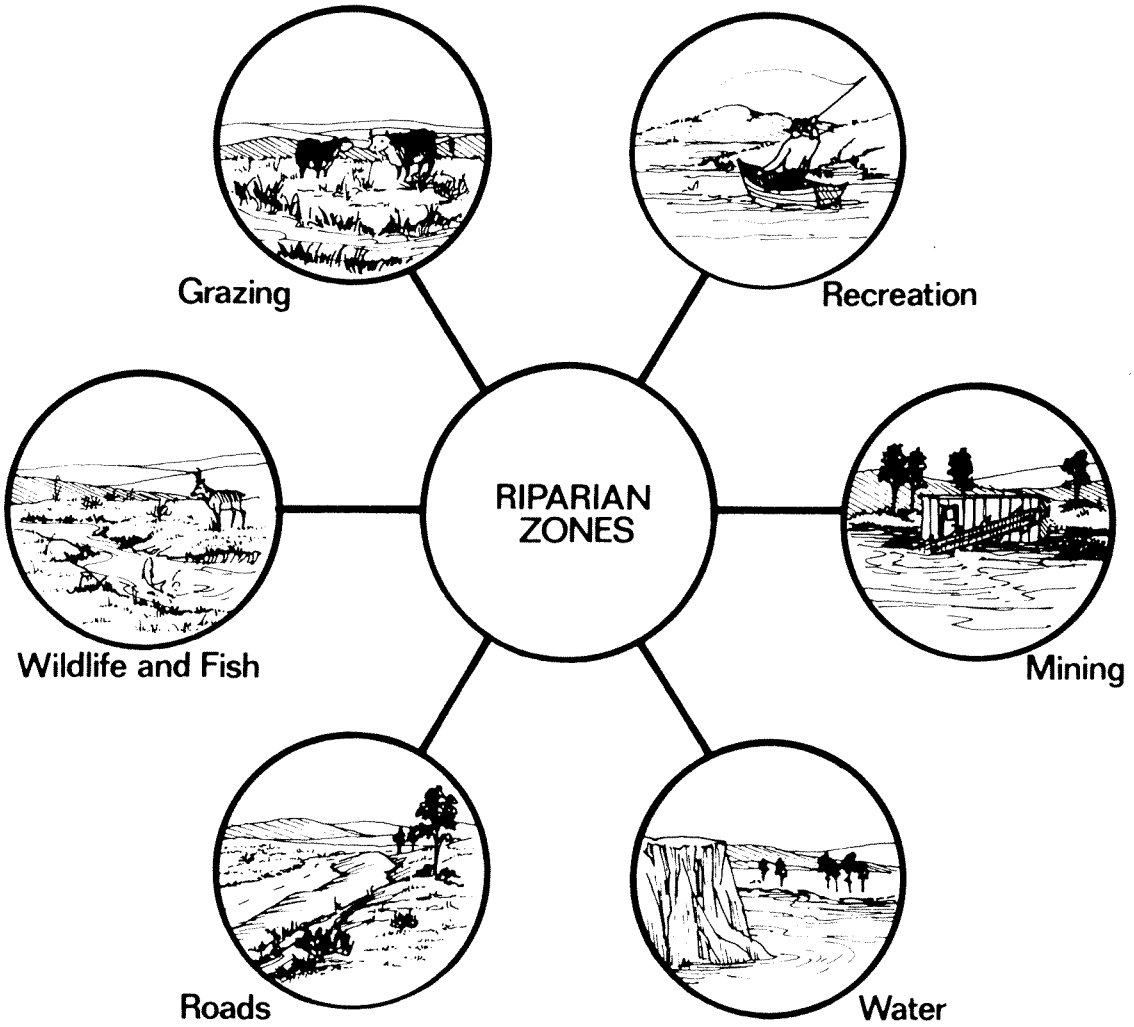


Figure 5.—Riparian zones are disproportionately important to many uses which makes them the most critical zones for multiple-use planning.

trate their use in such areas (Nash 1977). In addition, scenic values are often high. The water in such zones, particularly on dry western ranges, is critical to man's use, and rangelands are second only to cultivated lands as a source of water quality problems (Satterlund 1975). As a result, riparian zones are the most critical zones for multiple-use planning (Countess et al. 1977, Fox 1977, Lewis and Marsh 1977, Likens and Bormann 1974, Tuinstra 1967).

There are many reasons why riparian zones are so important to wildlife. Not all of these can be attributed to every riparian zone. Each combination of water source, site attributes, and management objectives must be considered separately by range managers. Some of these reasons are discussed below:

1. The presence of water lends importance to the zone. Wildlife habitat is composed of food, cover, and water. All riparian zones offer water, one of the critical habitat components, and some offer all three.

2. The greater availability of water to plants, frequently in combination with deeper soils, increases plant biomass production and provides a suitable site for plants that are limited elsewhere by inadequate water

Figure 6.—Mining activity has been frequently located in or adjacent to riparian zones causing severe disturbance. (Robert R. Kindschy photograph).

(Minore 1970, Minore and Smith 1971). In combination, these factors frequently lead to increased diversity of plant species and structural diversity in the community. Much of the diversity in species composition is accounted for by the presence of plants particularly adapted to wet or moist conditions, particularly those provided by surface as opposed to ground water (Campbell and Green 1968, Horton 1972, Maximov 1931). In the management sense, this means that riparian zones generally have a high rate of recovery or successional advancement of the vegetation when afforded proper conditions by protection or appropriate management.

3. The dramatic contrasts of the plant complex of the riparian zone with the general surrounding upland range vegetation adds to the structural diversity of the area (Jain 1976). For example, open wet meadows or groves of deciduous trees around seeps provide edges with stark contrast when they, in turn, are surrounded by relatively drier grasslands or shrublands. Moreover, those riparian zones dominated by deciduous vegetation provide one type of habitat during the summer when in full-leaf and another type of habitat during the winter following leaf-fall (Anderson and Ohmart 1977).

4. The shape of many riparian zones, particularly the linear nature of streams, maximizes the development of edge which is so productive of wildife (Bottorff 1974, Patton 1975). In those cases where streams flow through canyons, the canyon walls combine with the riparian zone to provide a unique habitat complex (fig. 7).

5. Riparian zones in rangelands frequently produce more edges within a small area than would be expected elsewhere (fig. 8). In addition, there are many vegetative strata exposed in stair-step fashion (fig. 8). This stair stepping of vegetation of contrasting form (deciduous vs. coniferous; shrubs vs. trees) provides diverse nesting and feeding opportunities for wildlife—especially birds and bats. The association of particular birds with distinct layers of vegetation has been repeatedly demonstrated (Dambach 1944, Lack 1933, MacArthur et al. 1962, Preston and Norris 1947, Thomas et al. 1977). In addition, birds have been shown to select between coniferous and deciduous vegetative volumes in distinct strata (DeGraaf 1976 and Thomas 1973).

Figure 7.—Where streams run through steep canyons, the cliff faces and the riparian zones combine to form a unique habitat unit. (Bureau of Land Management photograph).

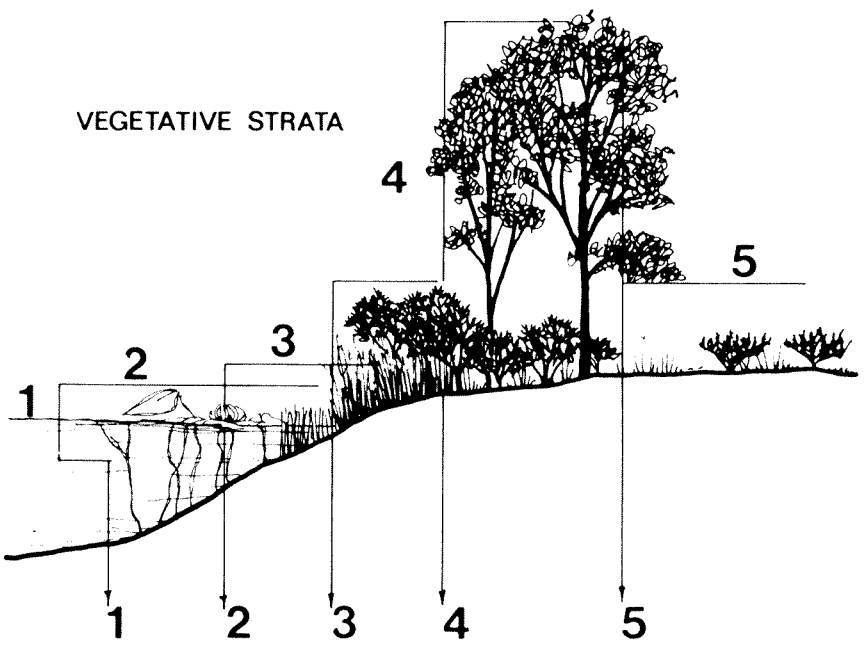


Figure 8.—Riparian zones frequently have a high number of edges and strata in a comparatively small area. This produces habitat for a greater number of species, reflecting the diversity of plant species and community structure.

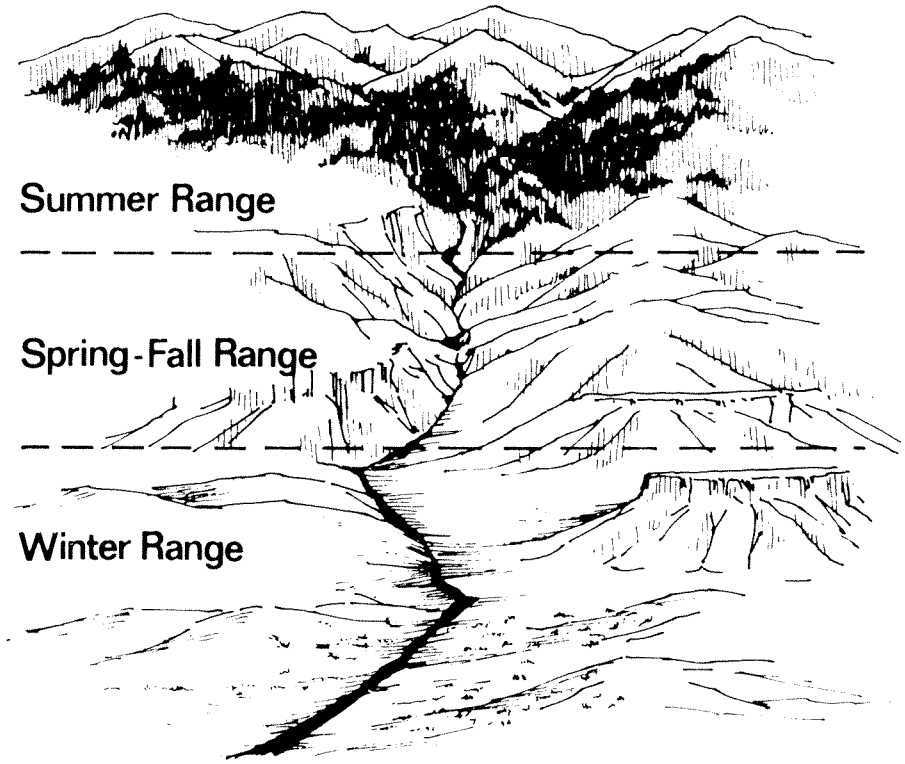


Figure 9.—Riparian zones along rivers and streams are frequently used as migration routes by wildlife. A migration corridor used by mule deer (*Odocoileus hemionus*) between summer range at high elevation and winter range at low elevation is illustrated.

6. The microclimate of riparian zones is different from that of the surrounding rangelands due to increased humidity, a higher rate of transpiration, more shade, and increased air movement. Some wildlife species are attracted to this microclimate. Mule deer (*Odocoileus hemionus*) spend a disproportionate amount of time in such areas due to the presence of cover that helps to maintain homeostasis or a condition where energy expenditure is minimized (see Thomas et al. 1979b for a review of this concept). The attraction of deer, elk, and other wild and domestic ungulates to these areas is caused by the abundance of thermal cover and the microclimate produced by that vegetation.

7. Riparian zones along intermittent and permanent streams and rivers provide migration routes for wildlife, such as birds, bats, deer, and elk (Stevens et al. 1977, Wauer 1977). In the case of deer and elk, such areas are frequently used as travel corridors between high elevation summer ranges and low elevation winter ranges (fig. 9).

8. Riparian zones, particularly along rivers and streams, may serve as forested connectors between habitats. Wildlife may use such riparian zones for cover while traveling across otherwise open areas. Some species, especially small mammals and birds may use such routes in dispersal from their original habitats caused by population pressure or food, water, or other shortage. The riparian zones provide cover and often provide food and water during such movements (fig. 10).

SENSITIVITY TO DISTURBANCE

Riparian zones occupy relatively small areas and should be considered vulnerable to severe alteration. Because of the distinct vegetative community and the structure of riparian zones, they must also be considered fragile. The more mature the vegetative complex of the riparian zone, the more apt it is to assume distinct edges and strata that intensify edge-effect and increase diversity. This mature condition is sensitive to management activities that occur within the riparian zone itself or on the surrounding rangeland (fig. 11).

The sensitivity of the vegetatively mature riparian zone as wildlife habitat can also be attributed to its distinct microclimate. Such

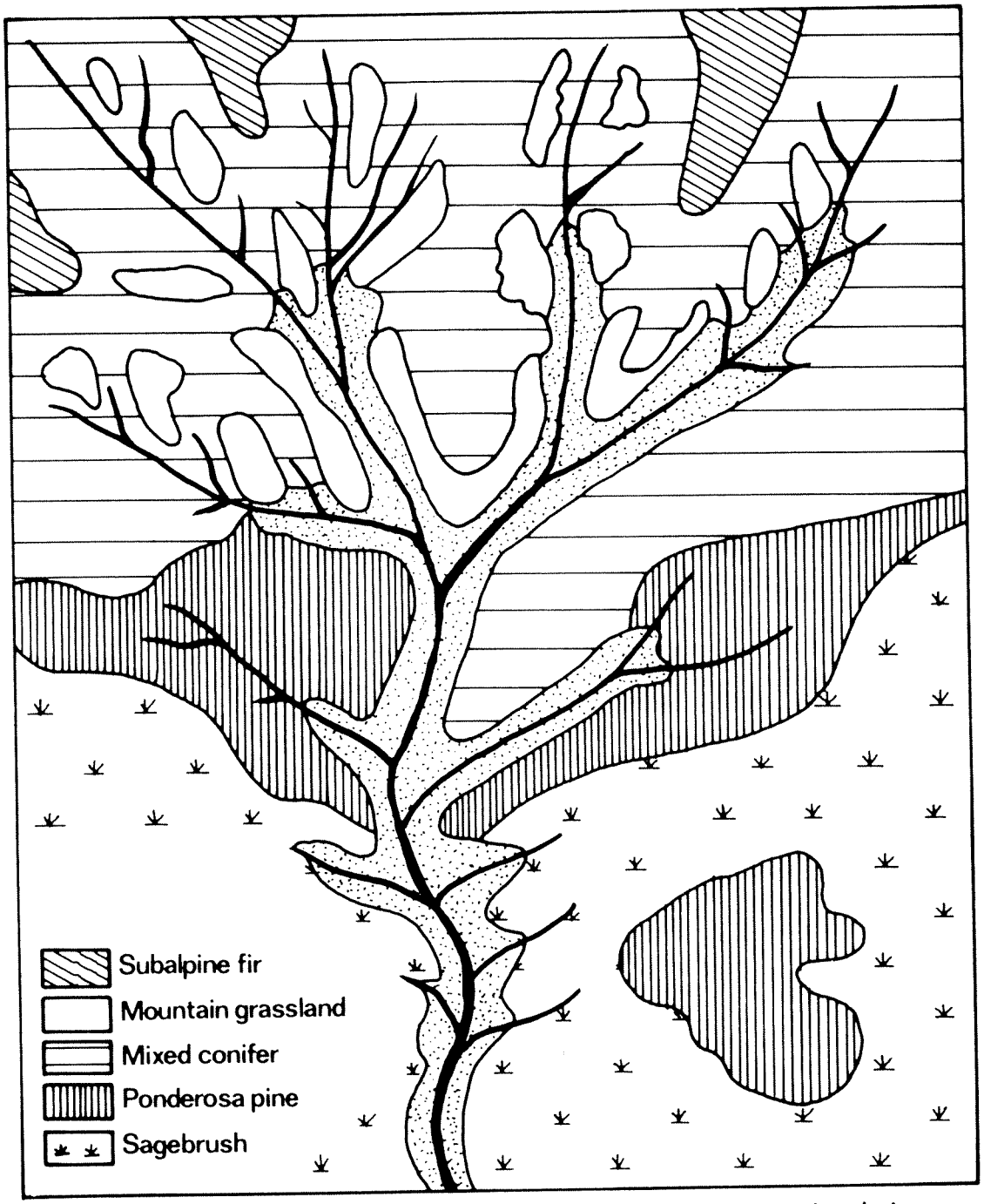
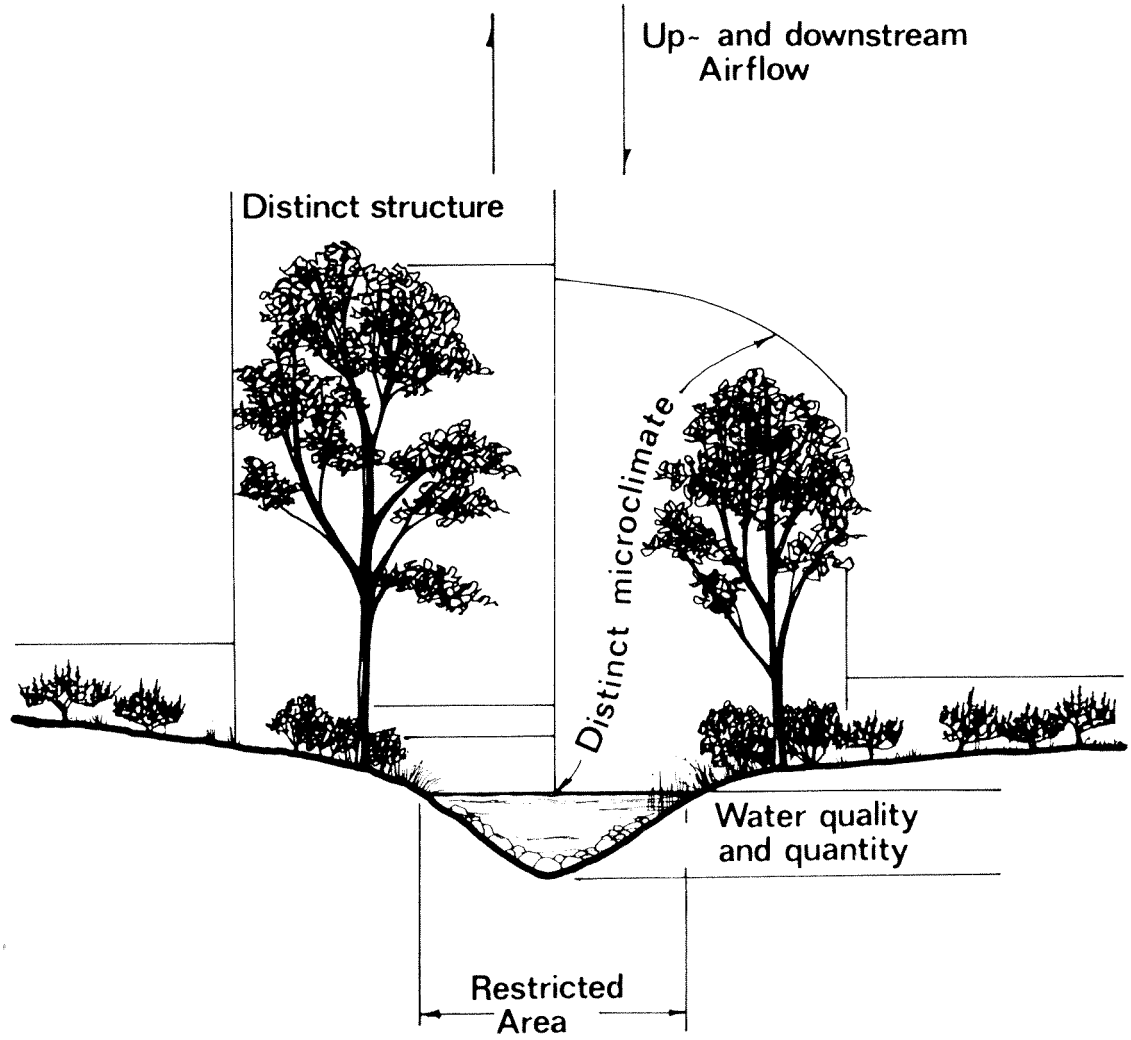


Figure 10.—Riparian zones along rivers and streams serve as connectors between habitat types; they provide cover, food, and water as the animals move from one location to another.

Figure 11.—Riparian zones must be considered as "delicate" due to the combination of restricted area, distinct microclimate, vegetative structure and composition, and water quantity and quality.



sensitivity includes both the terrestrial portions of the riparian zone and the characteristics of water quality (including temperature) of the associated aquatic zone (Boussu 1954, Gunderson 1968, Tuinstra 1967). Changes in the canopy cover can alter these characteristics markedly (Brown et al. 1971, Brown and Krygier 1967, Collings and Myrick 1966, Cordone and Kelley 1961, Meehan 1970). For example, an increase of a few degrees in water temperature may eliminate a stream as a trout fishery.

MANAGEMENT CONSIDERATIONS

Riparian zones are so different from one another that generalized animal-to-habitat relationships are difficult to develop for these areas. To do a good management job with such areas, one must derive a specific set of relationships for each particular case. Rangeland managers should consult both fishery and wildlife biologists when management activities are planned within the riparian zone. The following considerations can be helpful:

1. Road construction in riparian zones will lessen the effectiveness of the zone as habitat for many wildlife species (fig. 12). This results from both the alteration in the vegetative complex and in the increased disturbance from traffic along the road. Increased sedimentation from road construction may be detrimental to water quality and hence to aquatic life. Many streams in managed rangelands are already paralleled by roads. Each time a new streamside road is considered, managers need to determine how much riparian habitat will be seriously impaired by such roads. This can be done by comparing the percent of streams with roads alongside of them with the percent of streams without roads. Road construction probably has a more critical and long-lasting impact on riparian zones than any other management activity.

2. The narrower the riparian zone the more easily it is altered by management action.

3. Construction of campgrounds in riparian zones enhances the opportunity for human-wildlife contacts but simultaneously decreases effectiveness of the riparian zone as wildlife habitat due to the disturbance by humans, trampling, soil erosion, compaction, and loss of vegetation (Aitchison 1977, Aitchison et al. 1977, Settergren 1977).

4. Improper grazing practices in riparian zones can reduce water quality, eliminate streamside shrubs, cause soil compaction, accelerate erosion, and breakdown streambanks (Ames 1977, Buckhouse and Gifford 1976, Coltharp and Darling 1973, Diesch 1970, Marcuson 1977, Winegar 1975). Proper grazing management should include particular attention to insuring the welfare of riparian zones.

If livestock grazing is to take place in a riparian zone, the environmental impact on the zone should be carefully evaluated. The heavier the grazing and the more prolonged the grazing period the more severe will be the impacts (fig. 13). The environmental impacts of grazing in such zones may be magnified be-

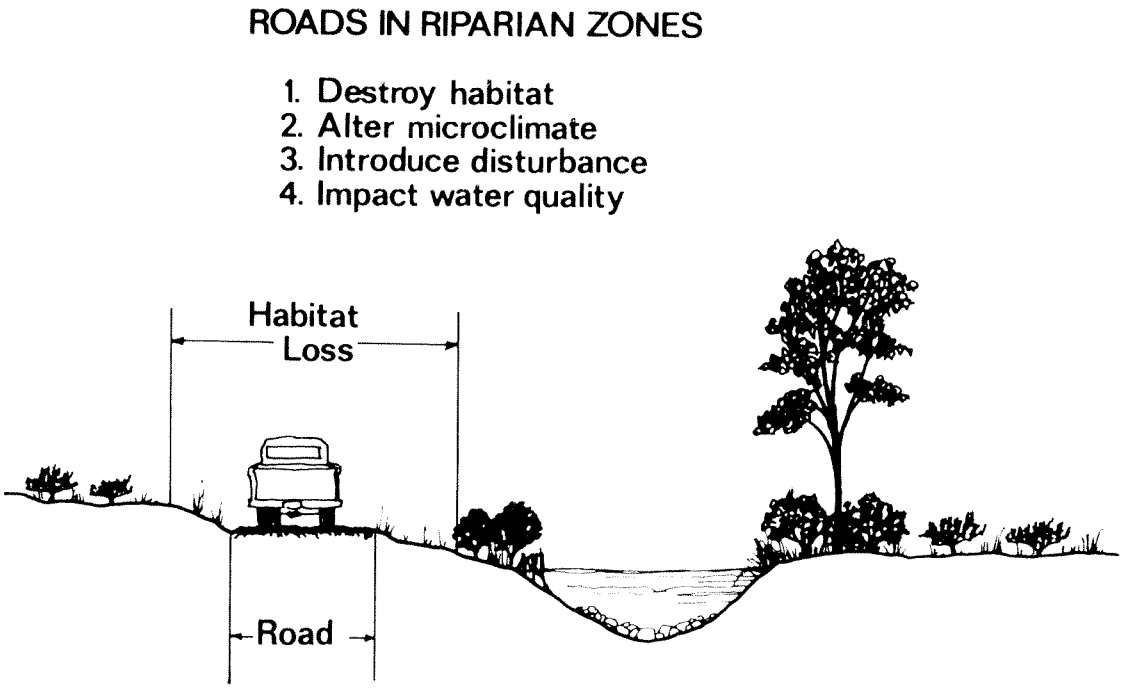


Figure 12.—Road construction in riparian zones reduces their usefulness as wildlife habitat. Roads in riparian zones: (1) alter vegetative structure, (2) alter microclimate, (3) reduce the size of riparian zones, (4) disturb the wildlife, (5) impact water quality in the aquatic zone, and (6) destroy the wildlife habitat.

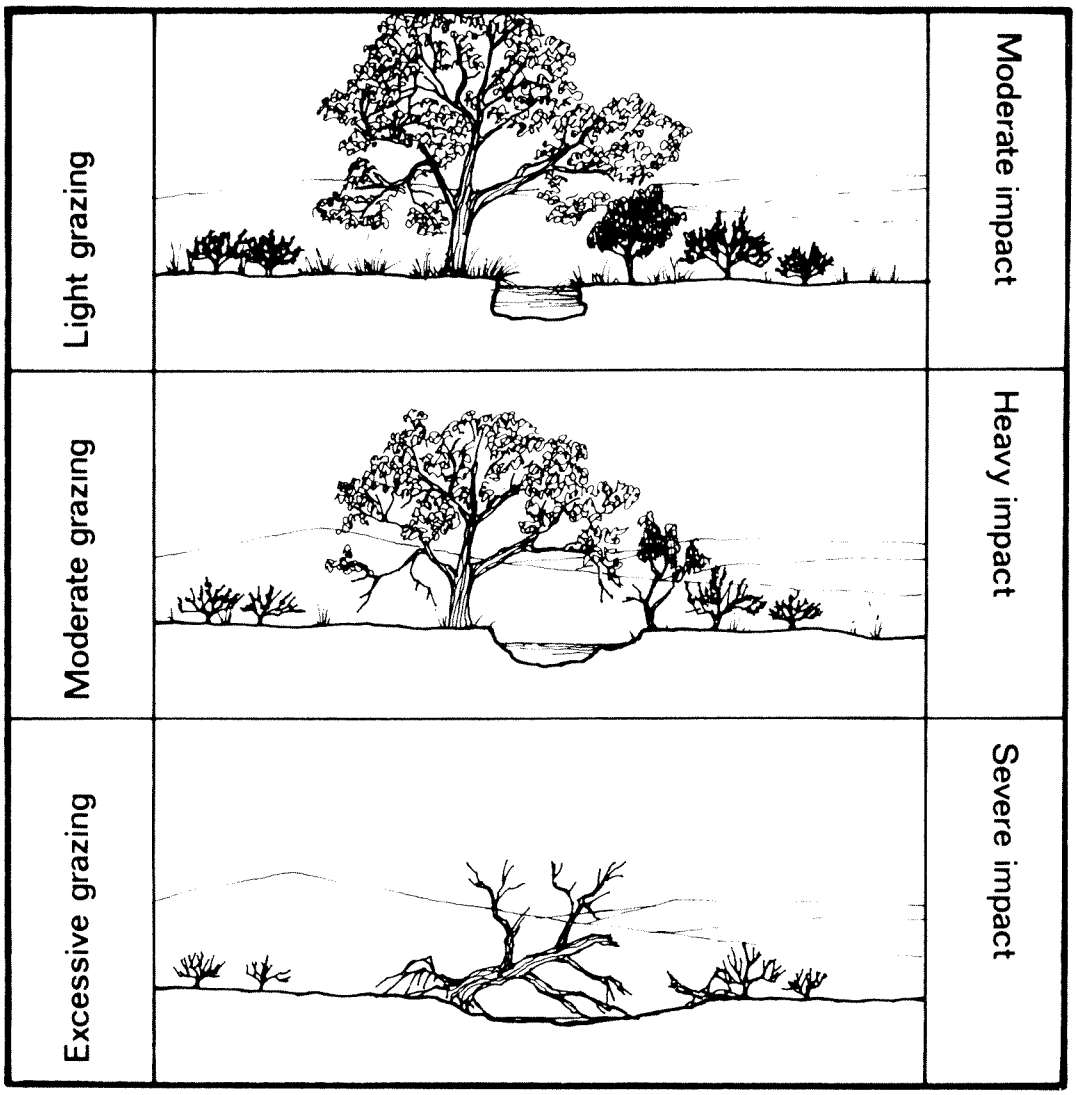


Figure 13.—When livestock are grazed in riparian zones, consideration of environmental impact is even more important than usual.

cause of the sensitivity of the microclimate and water temperature to increases in solar radiation reaching the ground or water surface. Some erosion disturbances are multiplied by proximity to the riparian zone. The key to prevention of surface erosion is the prevention or lessening of overland flow which is related to infiltration of precipitation. Infiltration may be enhanced by the maintenance of plant cover, both alive and dead. Under excessive grazing, livestock not only remove protective ground cover but also compact the soil, both of which accelerate erosion (Dambach 1944, Satterlund 1975).

Springs and seeps are often associated with relatively small, wet meadows. These meadows are critical to the existence of animals such as the montane vole (*Microtus montanus*) which, in turn, is food for many other vertebrates. Satterlund (1975, p. 24) observed:

> Meadows along stream channels are likely to be among the most productive parts of the range [in terms of livestock forage] because of the greater amount of water available for plant growth. Further, this same

> moistness makes them more susceptible to compaction. And finally, most animals [livestock] prefer to stay near available water, so this area receives the greatest impact of animal use. Therefore, these areas are key considerations in the prevention of erosion.

Development of seeps and springs for livestock (collecting the water into tanks and troughs) usually lessens the habitat value for wildlife (Heady and Bartolome 1977, USDA Soil Conservation Service 1967). When developing seeps and springs, one can increase values to wildlife by fencing the meadow surrounding a spring or seep to exclude livestock and piping the necessary water outside of the exclosure into troughs or other storage facilities (fig. 14). Small, wet meadows can also be created by piping overflow water from livestock troughs into fenced areas thereby creating and maintaining such meadows. A combination of the above techniques will provide the greatest area of "wet" habitat and, therefore, the greatest production of these rare and highly productive wildlife habitats.

5. Location of water impoundments are important if maximum benefits to wildlife are to be realized. Some areas which potentially receive the heaviest animal use are mature and decadent stands of western juniper (*Juniperus occidentalis*) and curlleaf mountain-mahogany (*Cercocarpus ledifolius*), cliffs, and edges between plant communities or structural conditions within plant communities (Maser et al. 1979, Maser and Gashwiler 1978, Thomas et al. 1978, Thomas et al. 1979c). Where water is a limiting factor, wildlife habitat may be created or enhanced by proper placement and design of water impoundments.

6. Although man-caused debris should be removed, a water source should not be "overcleaned." Leave moderate amounts of stable debris intact since it serves as critical, small habitats—usually for reproduction of small animals.

7. Recreational use per unit area of the riparian zone is many times that of other vegetative types (Heberlein 1977, Lewis and Marsh 1977, USDA Forest Service 1977). The impact of such use on wildlife varies with the season and type, intensity, and duration of use (Kuska 1977, Pfister 1977). Construction of trails, picnic tables, and docks encourages recreational use and increases the potential for conflicts with wildlife welfare.

8. Range management activities that take place outside the riparian zone may have impact on the riparian zone itself by changing the quantity and quality of water entering and in-

Figure 14.—Wildlife habitat can be maintained and/or enhanced by fencing a meadow surrounding a spring or seep to exclude livestock. The necessary water can then be piped outside of the exclosure into troughs, and by piping overflow water from livestock troughs into fenced areas, small, wet meadows can be created and maintained.

fluencing the riparian zones (Buckhouse 1975, Environmental Protection Agency 1976). Of the many factors that influence the amount of surface erosion and subsequent water quality, some can be controlled through management action, and the most important action is the maintenance of appropriate vegetative cover and soil conditions (Satterlund 1975). These influences may involve changes in suspended solids, nutrients, electrical conductance, and minerals as well as water temperature and water volume (Hibbert et al. 1974, 1975, Sharpe 1975). Leopold (1941, p. 17) put it this way: "Soil and water are not two organic systems, but one. Both are organs of a single landscape; a derangement in either affects the health of both...."

9. Any grazing management scheme that is instituted with the idea of preserving, enhancing, or reestablishing woody vegetation along streamsides or other riparian zones must consider the physiology of these plants and their response to grazing. Standard grazing systems, such as continuous rest rotation or deferred rotation (Heady 1975), in various forms, have generally been developed considering only the production and maintenance of forage plants—primarily grasses and forbs. It is likely that the application of such systems to maintain woody streamside vegetation and streambank integrity will not be satisfactory until the physiology of shrubs and trees is given consideration equal to forage plants.

Information on how grazing systems may be used to accomplish such goals as maintenance of woody streambank vegetation and the prevention of bank crumbling and soil compaction is only now being derived by experience and research. It is likely that special systems may have to be instituted, such as six or more pastures in the rotation grazing systems (compared to the presently standard two to five pastures) or complete protection for some period coupled with restricted grazing after satisfactory conditions are achieved.

"Business as usual" has resulted in deterioration of many riparian wildlife and fish habitats. New approaches to grazing management in riparian zones may be required to restore or maintain the fish and wildlife habitat values of this most critical zone.

A "RED FLAG" FOR RIPARIAN ZONES

The riparian zone is the most important wildlife habitat type in the managed rangelands. It is also the area of maximum potential conflict between users of timber, grazing, recreation, water, and wildlife resources. Riparian zones are usually quite sensitive to management activities and should be cautiously managed (Beschta 1978). As each riparian zone is somewhat different, the land manager should consult a wildlife biologist and a fishery biologist during the planning process if fish and wildlife welfare are objectives of management. The purpose of this chapter has been to raise a "red flag" where riparian zones are concerned. Habitat alterations will affect wildlife far more than indicated by the proportion of the total area disturbed.

Literature Cited

Aitchison, Stewart W.
1977. Some effects of a campground on breeding birds in Arizona. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 175-182. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Aitchison, Stewart W., Steven W. Carothers, and R. Roy Johnson.
1977. Some ecological considerations associated with river recreation management. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 222-225. North Cent. For. Exp. Stn., St. Paul, Minn.

Ames, Charles R.
1977. Wildlife conflicts in riparian management: Grazing. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 49-51. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Anderson, Bertin W., and Robert D. Ohmart.
1977. Vegetation structure and bird use in the lower Colorado River Valley. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 23-24. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Beidleman, R. G.
1948. The vertebrate ecology of a Colorado cottonwood river bottom. M.S. thesis. Univ. Colo., Boulder. 351 p.

Beidleman, R. G.
1954. The cottonwood river-bottom community as a vertebrate habitat. Ph.D. thesis. Univ. Colo., Boulder. 358 p.

Beschta, Robert L.
1978. Inventorying small streams and channels on wildland watersheds. *In* Integrated Inventories of Renewable Natural Resources: Proceedings of the Workshop. H. Gyde Lund, Vernon J. LaBau, Peter F. Ffolliott, and David Robinson (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-55, p. 104- 113. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Bottorff, R. L.
1974. Cottonwood habitats for birds in Colorado. Am. Birds 28(6):975-979.

Boussu, Marvin F.
1954. Relationship between trout populations and cover on a small stream. J. Wildl. Manage. 18(2):229-239.

Brown, George W., and James T. Krygier.
1967. Changing water temperatures in small mountain streams. J. Soil and Water Conserv. 22(6):242-244.

Brown, George W., Gerald W. Swank, and Jack Rothacher.
1971. Water temperature in the Steamboat drainage. USDA For. Serv. Res. Pap. PNW-119, 17 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Buckhouse, John C.
1975. Water quality impact of burning and grazing on a chained pinyon-juniper site in southeastern Utah. Ph.D. thesis, Utah State Univ., Logan. 103 p.

Buckhouse, John C., and Gerald F. Gifford.
1976. Water quality implications of cattle grazing on a semi-arid watershed in southeastern Utah. J. Range Manage. 29(2):109-113.

Campbell, C. J.
1970. Ecological implications of riparian vegetation management. J. Soil and Water Conserv. 25(2):49-52.

Campbell, C. J., and W. Green.
1968. Perpetual succession of stream-channel vegetation in a semi-arid region. J. Ariz. Acad. Sci. 5(2):86-98.

Carothers, Steven W.
1977. Importance, preservation, and management of riparian habitats: An overview. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43,

p. 2-4. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Carothers, Steven W., and R. Roy Johnson.
1975. Water management practices and their effects on nongame birds in range habitats. *In* Proceedings of the Symposium on Management of Forest and Range Habitats for Nongame birds, edited by D. R. Smith. USDA For. Serv. Gen. Tech. Rep. WO-1, p. 210-222. Washington, D.C.

Collings, M. R., and R. M. Myrick.
1966. Effects of juniper and pinyon eradication on stream flow from Corduroy Creek Basin, Arizona. Geol. Surv. Prof. Pap. 491-B, 12 p.

Coltharp, George B., and Leslie A. Darling.
1973. Livestock grazing—a non-point source of water pollution in rural areas? Rural Environ. Eng. Symp., p. 341-358. Univ. Vermont, Burlington.

Cordone, Almo J., and Don E. Kelley.
1961. The influence of inorganic sediment on the aquatic life of streams. Calif. Fish and Game 47(2):189-228.

Countess, Michael L., Walter L. Criley, and B. R. Allison.
1977. Problems and conflicts associated with river recreation programming and management in the east. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 147-150. North Cent. For. Exp. Stn., St. Paul, Minn.

Curtis, Robert L., and Thomas H. Ripley.
1975. Water management practices and their effect on nongame bird habitat values in a deciduous forest community. *In* Proceedings of the Symposium on Management of Forest and Range Habitats for Nongame Birds, edited by D. R. Smith. USDA For. Serv. Gen. Tech. Rep. WO-1, p. 128-141. Washington, D.C.

Dambach, Charles A.
1944. A ten-year ecological study of adjoining grazed and ungrazed woodlands in northeastern Ohio. Ecol. Monogr. 14(3):257-270.

DeGraaf, Richard Matthew.
1976. Suburban habitat associations of birds. Ph.D. thesis, Univ. Mass., Amherst. 317 p.

Diesch, Stanley L.
1970. Disease transmission of waterborne organisms of animal origins. *In* Agricultural Practices and Water Quality, edited by T. L. Willrich and G. E. Smith, p. 265-285. Iowa State Univ. Press, Ames.

Dumas, Philip C.
1950. Habitat distribution of breeding birds in southeastern Washington. Condor 52(5):232-237.

Environmental Protection Agency.
1976. Forest harvest, residue treatment, reforestation and protection of water quality. EPA 910/9-76-020. Reg. 10, 273 p. Natl. Tech. Inf. Serv., Springfield, Va.

Fox, Kel.
1977. Importance of riparian ecosystems: Economic considerations. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 19-22. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Franklin, Jerry F., and C. T. Dyrness.
1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8, 417 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Gains, David A.
1977. Chapter 7. The valley riparian forests of California: Their importance to bird populations. *In* Riparian Forest in California: Ecology and Conservation, Anne Sands (ed.). Inst. Ecol. Publ. No. 15, p. 57-85. Univ. Calif., Davis.

Gunderson, Donald R.
1968. Floodplain use related to stream morphology and fish populations. J. Wildl. Manage. 32(3):507-514.

Heady, Harold F.
1975. Rangeland management. 460 p. McGraw-Hill Inc., New York.

Heady, Harold F., and James Bartolome.
1977. The Vale rangeland rehabilitation program: The desert repaired in southeastern Oregon. USDA For. Serv. Resour. Bull. PNW-70, 139 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Heberlein, Thomas A.
1977. Density, crowding, and satisfaction: Sociological studies for determining carrying capacities. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 67-76. North Cent. For. Exp. Stn., St. Paul, Minn.

Hibbert, Alden R., Edwin A. Davis, and David G. Scholl.
1974. Chaparral conversion potential in Arizona. Part 1: Water yield response and effects on other resources. USDA For. Serv. Res. Pap. RM-126, 36 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Hibbert, Alden R., Edwin A. Davis, and Thomas C. Brown.
1975. Managing chaparral for water and other resources in Arizona. *In* Watershed Management Symposium, p. 445-468. ASCE Irrigation and Drainage Division, Logan, Utah.

Hill, Ronald D.
1974. Mining impacts on trout habitat. *In* USDA Forest Service Symposium on Trout Habitat Research and Management Proceedings, p. 47-57. Southeast. For. Exp. Stn., Asheville, N.C.

Hinschberger, Mark Steven.
1978. Occurrence and relative abundance of small mammals associated with riparian and upland habitats along the Columbia River. M.S. thesis, Oreg. State Univ., Corvallis. 78 p.

Horton, Jerome S.
1972. Management problems in phreatophyte and riparian zones. J. Soil and Water Conserv. 27(2):57-61.

Hubbard, John P.
1977. Importance of riparian ecosystems: Biotic considerations. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 14-18. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Jain, Subodh (ed.)
1976. Vernal pools—their ecology and conservation. Inst. Ecol. Publ. No. 9, 93 p. Univ. Calif, Davis.

Kelly, W., R. Hubbell, S. Loe, and L. Shikany.
1975. Management of riparian habitats. USDA For. Serv. Coord. Guides for Wildl. Hab. No. 9, 9 p. Calif. Reg.

Kennedy, Charles E.
1977. Wildlife conflicts in riparian management: Water. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 52-58. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Kirby, Ronald E.
1975. Wildlife utilization of beaver flowages on the Chippewa National Forest, North Central Minnesota. Loon 47(4): 180-185.

Kuska, James J.
1977. Biological approach to river planning and management. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 296-303. North Cent. For. Exp. Stn., St. Paul, Minn.

Lack, David.
1933. Habitat selection in birds, with special reference to the effects of afforestation on the Breckland avifauna. J. Anim. Ecol. 2(2):239-262.

Leopold, Aldo.
1941. Lakes in relation to terrestrial life patterns. In Univ. Wisconsin Symposium, Volume on Hydrology, p. 17-22. Madison.

Lewis, Darrell E., and Gary G. Marsh.
1977. Problems resulting from the increased recreational use of rivers in the west. *In* Proceedings, River Recreation Management and Research Symposium.

USDA For. Serv. Gen. Tech. Rep. NC-28, p. 27-31. North Cent. For. Exp. Stn., St. Paul, Minn.

Likens, Gene E., and F. Herbert Bormann.
1974. Linkages between terrestrial and aquatic ecosystems. BioScience 24(8): 447-456.

MacArthur, Robert H., John W. MacArthur, and James Preer.
1962. On bird species diversity. II. Prediction of bird census from habitat measurements. Am. Nat. 96(888):167-174.

Marcuson, Patrick E.
1977. The effect of cattle grazing on brown trout in Rock Creek, Montana. Mont. Dep. Fish and Game, Fish. Div., Spec. Rep. Proj. No. F-20-R-21, II-a. 26 p.

Maser, Chris, and Jay S. Gashwiler.
1978. Interrelationships of wildlife and western juniper. *In* Proceedings of the Western Juniper Ecology and Management Workshop, Robert E. Martin, J. Edward Dealy, and David L. Carather (eds.). USDA For. Serv. Gen. Tech. Rep. PNW 74, p. 37-82. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Maser, Chris, Jon E. Rodiek, and Jack Ward Thomas.
1979. Cliffs, talus, and caves. *In* Wildlife Habitats in Managed Forests — The Blue Mountains of Oregon and Washington. Jack Ward Thomas (Tech. Ed.) U.S. Dep. Agric. Agric. Handb. 553. (In press.)

Maximov, N. A.
1931. The physiological significance of the xeromorphic structure of plants. J. Ecol. 19(2):273-282.

Meehan, William R.
1970. Some effects of shade cover on stream temperature in Southeast Alaska. USDA For. Serv. Res. Note PNW-113, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Minore, Don.
1970. Seedling growth of eight northwestern tree species over three water tables. USDA For. Serv. Res. Note PNW-115, 8 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Minore, Don, and Clark E. Smith.
1971. Occurrence and growth of four northwestern tree species over shallow water tables. USDA For. Serv. Res. Note PNW-160, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Nash, Roderick.
1977. River recreation: History and future. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 2-7. North Cent. For. Exp. Stn., St. Paul, Minn.

Odum, Eugene P.
1971. Fundamentals of ecology — third edition. 574 p. W. B. Saunders Co., Philadelphia, Penn.

Patton, David R.
1975. A diversity index for quantifying "edge." Wildl. Soc. Bull. 3(4):171-173.

Pfister, Robert E.
1977. Campsite choice behavior in the river setting: A pilot study on the Rogue River, Oregon. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 351-358. North Cent. For. Exp. Stn., St. Paul, Minn.

Preston, F. W., and R. T. Norris.
1947. Nesting heights of breeding birds. Ecology 28(3):241-273.

Satterlund, Donald R.
1975. The water resource in range ecosystems management. *In* Range, Multiple Use Management, p. 19-26. Wash. State Univ., Oreg. State Univ., Univ. of Idaho.

Settergren, Carl D.
1977. Impacts of river recreation use on streambank soils and vegetation—state-of-the-knowledge. *In* Proceedings, River Recreation Management and Research Symposium. USDA For. Serv. Gen. Tech. Rep. NC-28, p. 55-59. North Cent. For. Exp. Stn., St. Paul, Minn.

Sharpe, William E.
1975. Timber management influences on aquatic ecosystems and recommendations for future research. Water Resour. Bull. 11(3): 546-550.

Stevens, Lawrence E., Bryan T. Brown, James M. Simpson, and R. Roy Johnson.
1977. The importance of riparian habitat to migrating birds. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 156-164. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Thomas, Jack Ward.
1973. The determination of habitat requirements for birds in suburban areas: A pilot study. Ph.D. diss., Univ. Mass., Amherst. 245 p.

Thomas, Jack Ward, Richard M. DeGraaf, and Joseph C. Mawson.
1977. Determination of habitat requirements for birds in suburban areas. USDA For. Serv. Res. Pap. NE-357, 15 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Thomas, Jack Ward, Chris Maser, and Jon E. Rodiek.
1978. Edges—their interspersion, resulting diversity and its measurement. *In* Proceedings of the Workshop on Nongame Bird Habitat Management in Coniferous Forests of the Western United States. Richard M. DeGraaf (Tech. Coordinator). USDA For. Serv. Gen. Tech. Rep. PNW-64, p. 91-100. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Thomas, Jack Ward, Chris Maser, and Jon E. Rodiek.
1979a. Riparian zones. *In* Wildlife Habitats in Managed Forests — The Blue Mountains of Oregon and Washington, Jack Ward Thomas (Tech. Ed.) U.S. Dep. Agric. Agric. Handb. 553. (In press.)

Thomas, Jack Ward, Hugh C. Black, Jr., Richard J. Scherzinger, and Richard J. Pedersen.
1979b. Deer and elk. *In* Wildlife Habitats in Managed Forests — The Blue Mountains of Oregon and Washington, Jack Ward Thomas (Tech. Ed.) U.S. Dep. Agric. Agric. Handb. 553. (In press.)

Thomas, Jack Ward, R. Miller, Chris Maser, Ralph Anderson, and Bernie Carter.
1979c. Plant communities and successional stages. *In* Wildlife Habitats in Managed Forests — The Blue Mountains of Oregon and Washington, Jack Ward Thomas (Tech. Ed.) U.S. Dep. Agric. Agric. Handb. 553. (In press.)

Tuinstra, K. E.
1967. Vegetation of the floodplains and first terraces of Rock Creek near Red Lodge, Montana. Ph.D. thesis. Montana State Univ., Bozeman. 110 p.

U.S. Department of Agriculture, Soil Conservation Service.
1967. National handbook for range and related grazing lands. U.S. Gov. Print. Off., Washington, D.C. 84 p.

U.S. Department of Agriculture, Forest Service.
1977. Proceedings-symposium on river recreation management and research. USDA For. Serv. Gen. Tech. Rep. NC-28, 455 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Wauer, Roland H.
1977. Significance of Rio Grande riparian systems upon the avifauna. *In* Importance, Preservation and Management of Riparian Habitat: A Symposium. R. Roy Johnson and Dale A. Jones (Tech. Coordinators). USDA For. Serv. Gen. Tech. Rep. RM-43, p. 165-174. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Winegar, Harold.
1975. Camp Creek: Rebirth of a section. Oreg. Wildl. 30(11):6-7.

Wooding, J.
1973. Census of the breeding birds of the Roaring Creek Watershed. Colo. Field Ornithol. 18:36-41.